CLAIMS

We claim:

1. An article of manufacture, comprising:

an organic structure and inorganic atoms bonded to selected locations on the organic structure.

2. The article of manufacture according to claim 1, wherein the inorganic atoms form an electrical conductor.

3. The article of manufacture according to claim 1, wherein the organic structure includes DNA.

4. A structure, comprising:

a DNA molecule including an R-loop; and

a nanoparticle bound to the DNA molecule in the interior of the R-loop.

5. The structure according to claim 4, wherein the nanoparticle is ferromagnetic, ferroelectric, or a semiconductor.

6. The structure according to claim 4, wherein the

structure forms a conductor to two sides of the R-loop.

7. The structure according to claim 5, wherein the nanoparticle includes at least one material selected from the group consisting of a semiconductor, a metal, and an alloy.

8. A structure, comprising:

an electrode positioned by a biomolecule; and

a nanoparticle spaced apart from the biomolecule.

9. A method for self assembly of inorganic material utilizing a self assembled organic template, the method comprising the steps of:

forming an organic structure; and

bonding inorganic atoms to selected locations on the organic structure.

10. A structure, comprising:

a substrate;

a first electrode and a second electrode on the substrate;

an organic molecule extending between the first electrode and the second electrode; and

a nanoparticle bonded to the organic molecule.

11. The structure according to claim 10, wherein the first electrode and the second electrode are gold.

12. The structure according to claim 10, wherein the organic molecule is DNA.

13. The structure according to claim 12, wherein the DNA is double stranded.

14. The structure according to claim 12, wherein the DNA is ë-DNA.

15. The structure according to claim 12, wherein the DNA molecule extending between the first electrode and the second electrode includes an R-loop and the nanoparticle is bonded to the DNA molecule inside the R-loop.

16. The structure according to claim 15, further comprising:

an RNA strand complementary to one strand of the DNA within the R-loop.

17. The structure according to claim 15, wherein at least one nucleotide is attached to the nanoparticle.

18. The structure according to claim 17, wherein the at least one nucleotide is complementary to at least one nucleotide of the DNA molecule within the R-loop.

19. The structure according to claim 17, wherein the at least one nucleotide is complementary to at least one nucleotide of the DNA molecule within the R-loop at a location equidistant from the first electrode and the second electrode.

20. The structure according to claim 10, further comprising:

an organic molecule bonded to a surface of the first electrode and the second electrode.

21. The structure according to claim 20, wherein the organic molecule bonded to the surface of the first electrode and the second electrode is DNA.

22. The structure according to claim 20, wherein the DNA molecule bonded to the surface of the first electrode

and the second electrode is sulfur terminated and single stranded.

23. The structure according to claim 21, wherein the DNA molecule bonded to the first electrode has a different sequence than the DNA molecule bonded to the second electrode.

24. The structure according to claim 21, wherein the DNA molecule bonded to the first electrode and the second electrode includes from five to twenty base pairs.

25. The structure according to claim 17, wherein the organic molecule extending between the first electrode and the second electrode is DNA.

26. The structure according to claim 25, wherein the DNA molecule extending between the first electrode and the second electrode includes an R-loop and the nanoparticle is bonded to the DNA molecule inside the R-loop.

27. The structure according to claim 26, further comprising:

an RNA strand complementary to one strand of the DNA

within the R-loop.

28. The structure according to claim 26, wherein at least one nucleotide is attached to the nanoparticle.

29. The structure according to claim 28, wherein the at least one nucleotide is complementary to at least one nucleotide of the DNA molecule within the R-loop.

30. The structure according to claim 28, wherein the at least one nucleotide is complementary to at least one nucleotide of the DNA molecule within the R-loop at a location equidistant from the first electrode and the second electrode.

31. The structure according to claim 25, wherein the DNA molecule extending between the first electrode and the second electrode is double stranded.

32. The structure according to claim 25, wherein the DNA is ë-DNA.

33. The structure according to claim 21, wherein the DNA molecule extending between the first electrode and the

second electrode includes sticky ends that hybridize with the DNA molecules bonded to the surface of the first electrode and second electrode.

34. The structure according to claim 10, further comprising:

an electrically conducting material on the organic molecule extending between the first electrode and the second electrode.

35. The structure according to claim 34, wherein the electrically conducting material includes silver ions bonded to phosphate groups of the DNA molecule.

36. The structure according to claim 34, wherein the electrically conducting material includes metallic silver on the DNA molecule.

37. The structure according to claim 10, further comprising:

a third electrode on the substrate between the first electrode and the second electrode.

38. The structure according to claim 37, wherein the

third electrode is equidistant from the first electrode and the second electrode.

39. The structure according to claim 37, wherein the third electrode has a width of about 100 nm to about 5000 nm.

40. The structure according to claim 37, wherein the third electrode has a width of less than 100 nm.

41. The structure according to claim 37, wherein the third electrode is perpendicular to the organic molecule extending between the first electrode and the second electrode.

42. The structure according to claim 37, wherein the organic molecule contacts the third electrode.

43. The structure according to claim 10, wherein the two electrodes are separated by a distance of about 1μm to about 100μm.

44. The structure according to claim 10, wherein the first electrode and the second electrode are made of a

material that includes gold.

45. The structure according to claim 10, wherein the first electrode and the second electrode are made of an oxide-free material.

46. The structure according to claim 10, wherein the first electrode and the second electrode terminate in sharp tips that face each other.

47. The structure according to claim 10, wherein the substrate is made of a material that includes a glass.

48. The structure according to claim 10, further comprising:

a fourth electrode positioned between the first electrode and the second electrode.

49. The structure according to claim 48, wherein the fourth electrode has a width of about 100 nm to about 5000 nm.

50. The structure according to claim 48, wherein the fourth electrode has a width of less than 100 nm.

51. The structure according to claim 48, wherein the fourth electrode is perpendicular to the organic molecule extending between the first electrode and the second electrode.

52. The structure according to claim 48, wherein the organic molecule contacts the third electrode and the fourth electrode.

53. The structure according to claim 52, wherein the electrodes and the organic molecule extending between the first electrode and the second electrode form an AND gate.

54. The structure according to claim 10, further comprising:

a third electrode and a fourth electrode on the substrate;

a second organic molecule extending between the third electrode and the fourth electrode; and

a nanoparticle bonded to the second organic molecule.

55. The structure according to claim 54, further comprising:

a fifth electrode on the substrate arranged at least between the first electrode and the second electrode; and

a sixth electrode on the substrate arranged at least between the third electrode and the fourth electrode.

56. The structure according to claim 55, wherein:

the organic molecules contact the fifth electrode and the sixth electrode; and

the electrodes and the organic molecules are electrically connected together to form an OR gate.

57. The structure according to claim 56, wherein one of the first electrode and the second electrode is electrically connected to one of the third electrode and the fourth electrode and the other of the first electrode and the second electrode is electrically connected to the other of the third electrode and the fourth electrode.

58. The structure according to claim 10, further comprising:

a plurality of nanoparticles bonded to the organic molecule.

59. A method, comprising the steps of:

forming a first electrode on a substrate;

forming a second electrode on a substrate;

extending an organic molecule between the first electrode and the second electrode; and

inserting at least one nanoparticle into at least one location in the organic molecule.

60. The method according to claim 59, further comprising the step of:

arranging an electrically conducting material on the organic molecule.

61. The method according to claim 59, further comprising the step of:

arranging an organic molecule on the first electrode and the second electrode.

62. The method according to claim 61, wherein the organic molecules extending between the first electrode and the second electrode and deposited on the first electrode and the second electrode are DNA molecules.

63. The method according to claim 62, wherein:

the DNA molecules attached to the first electrode and

the second electrode are single-stranded, sulfur-terminated, include from about five to about twenty bases, and have different sequences of bases; and

the DNA molecule extending between the first electrode and the second electrode includes sticky ends complementary to and hybridizing with the DNA molecules attached to the first electrode and the second electrode.

64. The method according to claim 62, further comprising the steps of:

attaching the DNA molecules to the first electrode and the second electrode; and

bonding the DNA molecule extending between the first electrode and the second electrode to the DNA molecule attached to the first electrode and the second electrode.

65. The method according to claim 64, further comprising the steps of:

forming at least one R-loop in the DNA molecule extending between the first electrode and the second electrode using at lease one RNA strand complementary to at least one portion of the DNA molecule extending between the first electrode and the second electrode; and

attaching a nanoparticle to a portion of the DNA in

each R-loop not attached to an RNA molecule.

66. The method according to claim 63, wherein the step of depositing an organic molecule on the first electrode and the second electrode comprises the steps of:

preparing a solution of the DNA molecule to be attached to the first electrode;

preparing a solution of the DNA molecule to be attached to the second electrode;

placing the first solution on one of the electrodes and the second solution on the other of the electrodes to permit a sulfur group to attach to the electrode; and

rinsing off the solution.

67. The method according to claim 66, further comprising the steps of:

dispensing a solution of the DNA molecule to extend between the first electrode and the second electrode onto the substrate between the first electrode and the second electrode; and

aligning between the first electrode and the second electrode the DNA molecule that is to extend between the first electrode and the second electrode.

68. The method according to claim 67, wherein the DNA molecule is aligned by inducing an electric field of a flow field between the two electrodes.

69. The method according to claim 68, further comprising the steps of:

forming an R-loop in the DNA molecule extending between the first electrode and the second electrode using an RNA strand complementary to a portion of the DNA molecule extending between the first electrode and the second electrode between the first electrode and the second electrode; and

attaching the nanoparticle to a portion of the DNA in the R-loop not attached to the RNA molecule.

70. The method according to claim 69, further comprising the step of:

functionalizing the nanoparticle with at least one nucleotide complementary to at least one base of the portion of the DNA loop within the R-loop prior to attaching it to the DNA within the R-loop.

71. The method according to claim 70, further comprising the step of:

forming a suspension of the nanoparticle; and

dispensing the suspension of the nanoparticle on the DNA molecule extending between the first electrode and the second electrode.

72. The method according to claim 71, further comprising the step of:

depositing an electrically conducting material on the DNA molecule extending between the first electrode and the second electrode.

73. The method according to claim 71, wherein the electrically conducting material is deposited on the DNA molecule extending between the first electrode and the second electrode by immersing the substrate in a silver-containing solution to form a silver salt with phosphate groups of the DNA molecule, the method further comprising the step of:

reducing the silver salt deposited on the DNA molecule extending between the first electrode and the second electrode to metallic silver.

74. The method according to claim 73, wherein reduction of the silver salt comprises the steps of:

exposing the silver salt to a reducing agent.

75. The method according to claim 74, wherein reduction of the silver salt comprises the steps of:

exposing the silver salt to hydroquinone/OH^- followed by hydroquinone/H^+.

76. The method according to claim 60, further comprising the step of:

providing a third electrode on the substrate between the first electrode and the second electrode.

77. The method according to claim 76, further comprising the steps of:

forming capacitive linkages between the electrically conducting material on the organic molecule and the third electrode.

78. The method according to claim 76, further comprising the steps of:

electrically connecting the electrically conducting material on the organic molecule and the third electrode to form an OR gate.

79. The method according to claim 60, further comprising:

providing a third electrode and a fourth electrode on the substrate;

extending a second organic molecule between the third electrode and the fourth electrode; and

at least one nanoparticle bonded to the second organic molecule.

80. The method according to claim 77, further comprising the steps of:

providing a fifth electrode on the substrate arranged at least between the first electrode and the second electrode; and

providing a sixth electrode on the substrate arranged at least between the third electrode and the fourth electrode.

81. The method according to claim 79, further comprising the step of:

electrically connecting the organic molecules and the electrodes to form an OR gate.

82. The method according to claim 79, further

comprising the step of:

electrically connecting one of the first electrode and the second electrode to one of the third electrode and the fourth electrode; and

electrically connecting the other of the first electrode and the second electrode to the other of the third electrode and the fourth electrode.

83. The method according to claim 59, wherein a plurality of nanoparticles are inserted into a plurality of locations on the organic molecule.

84. A method for controlling a device that includes a substrate, a first electrode and a second electrode on the substrate, an organic molecule extending between the first electrode and the second electrode, a nanoparticle bonded to the organic molecule, and an electrically conducting material on the organic molecule, the method comprising the steps of:

creating a bias in the electrically conducting material; and

regulating a charge in the nanoparticle to effect a change in the current in the electrically conducting material to effect a change in the current in the

13 electrically conducting material.